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Understanding soil phosphorus systems from emergent phosphorus behaviour in a headwater catchment

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Knowledge of soil phosphorus (P) sources and pathways is essential for predicting P transfers to water in the future, when drivers of P biogeochemistry may change under climate and land use change. However, the understanding of high frequency phosphorus dynamics has been limited by data of insufficient temporal resolution. This study shows how observing the patterns shown by headwater catchment systems can help to improve understanding of soil system science.

The study describes analysis of 15 minute resolution data of rainfall and river discharge, and 30 minute resolution data of total phosphorus (TP) and total reactive phosphorus (TRP) concentrations from a sub-basin of the River Eden catchment, Cumbria, UK, collected by the Defra Demonstration Test Catchment Programme. The analysis focussed on extreme events and event sequences, which are predicted to occur more frequently under a changing climate, such as periods of drying followed by heavy rainfall. Events were classified according to exceedance of discharge and P concentration thresholds (Type 1 = high discharge, low TP; Type 2 = high discharge, high TP; Type 3 = low discharge, high TP).

More than 75% of the TP load was transported during the 5% of the time with highest river discharge, with more than 69% of the TP load transferred in Type 2 events (< 4% in Type 1 events). High phosphorus concentrations in the river were also recorded during rainfall events following a dry period, when there was little response in discharge (Type 3, which accounted for less than 2% of total load). A lag of around one hour between peak TP and peak TRP concentrations indicated different pathways, with TP influenced by quickly mobilised sources, such as a readily available soil P pool, and fast pathways. In contrast, TRP showed a slower response indicating the presence of slower sub-surface pathways. Improved understanding of these processes will help in understanding the importance and availability of soil P pools in order to help farmers to plan sustainable phosphorus use and appropriate land management.